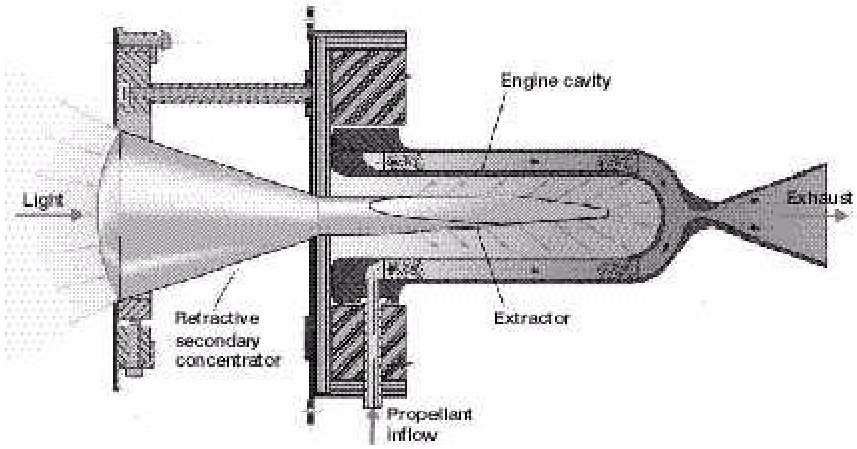
High-Efficiency Solar Thermal Vacuum Demonstration Completed for Refractive Secondary Concentrator

Common to many of the space applications that utilize solar thermal energy--such as electric power conversion, thermal propulsion, and furnaces--is a need for highly efficient, solar concentration systems. An effort is underway at the NASA Glenn Research Center to develop the refractive secondary concentrator, which uses refraction and total internal reflection to efficiently concentrate and direct solar energy. When used in combination with advanced lightweight primary concentrators, the refractive secondary concentrator enables very high system concentration ratios (10,000 to 1) and very high temperatures (>2000 K).

The innovative refractive secondary concentrator offers significant advantages over all other types of secondary concentrators. The refractive secondary offers the highest throughput efficiency, provides for flux tailoring, requires no active cooling, relaxes the pointing and tracking requirements of the primary concentrator, and enables very high system concentration ratios. This technology has broad applicability to any system that requires the conversion of solar energy to heat. Glenn initiated the development of the refractive secondary concentrator in support of Shooting Star, a solar thermal propulsion flight experiment, and continued the development in support of Space Solar Power.

Glenn's Thermo-Mechanical Systems Branch has completed a performance evaluation of a prototype refractive secondary concentrator in Glenn's Tank 6 solar thermal vacuum facility using a low-temperature liquid-cooled calorimeter. The effort involved the design and fabrication of a sapphire refractive secondary concentrator, design and fabrication of a calorimeter and its support systems, calibration of the calorimeter, on-sun vacuum testing of the refractive secondary, and comparing the test results with modeling predictions.

The sapphire refractive secondary concentrator enables high-temperature solar power and propulsion applications.



The refractive secondary concentrator provides efficient delivery of solar energy to a solar thermal propulsion engine.

The prototype refractive secondary concentrator, measuring 3.5 in. in diameter and 11.2 in. long, was designed for the Tank 6 facility and the existing primary concentrator/solar simulator system. Ray trace optics software was used to model the secondary concentrator, resulting in a predicted efficiency of 90 percent without an antireflective coating. For the test, input power to the refractive secondary ranged between 400 to 1200 W. Test results indicate an average throughput efficiency of 87 percent, which agrees well with the modeling predictions. We anticipate that using an antireflective coating to reduce the reflection loss at the inlet surface of the concentrator would result in a secondary concentrator throughput efficiency of approximately 93 percent. Potential future activities to further develop the technology include high-temperature, high-power throughput tests, antireflective coating tests, and additional material characterization and interaction tests.

Find out more about Glenn's Secondary Solar Concentrators (http://www.grc.nasa.gov/WWW/tmsb/secondconc.html).

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